EUROTrough Progress and "NEXTrough" Opportunities for an Euro-American Trough Alliance

Trough Meeting

SUNLAB

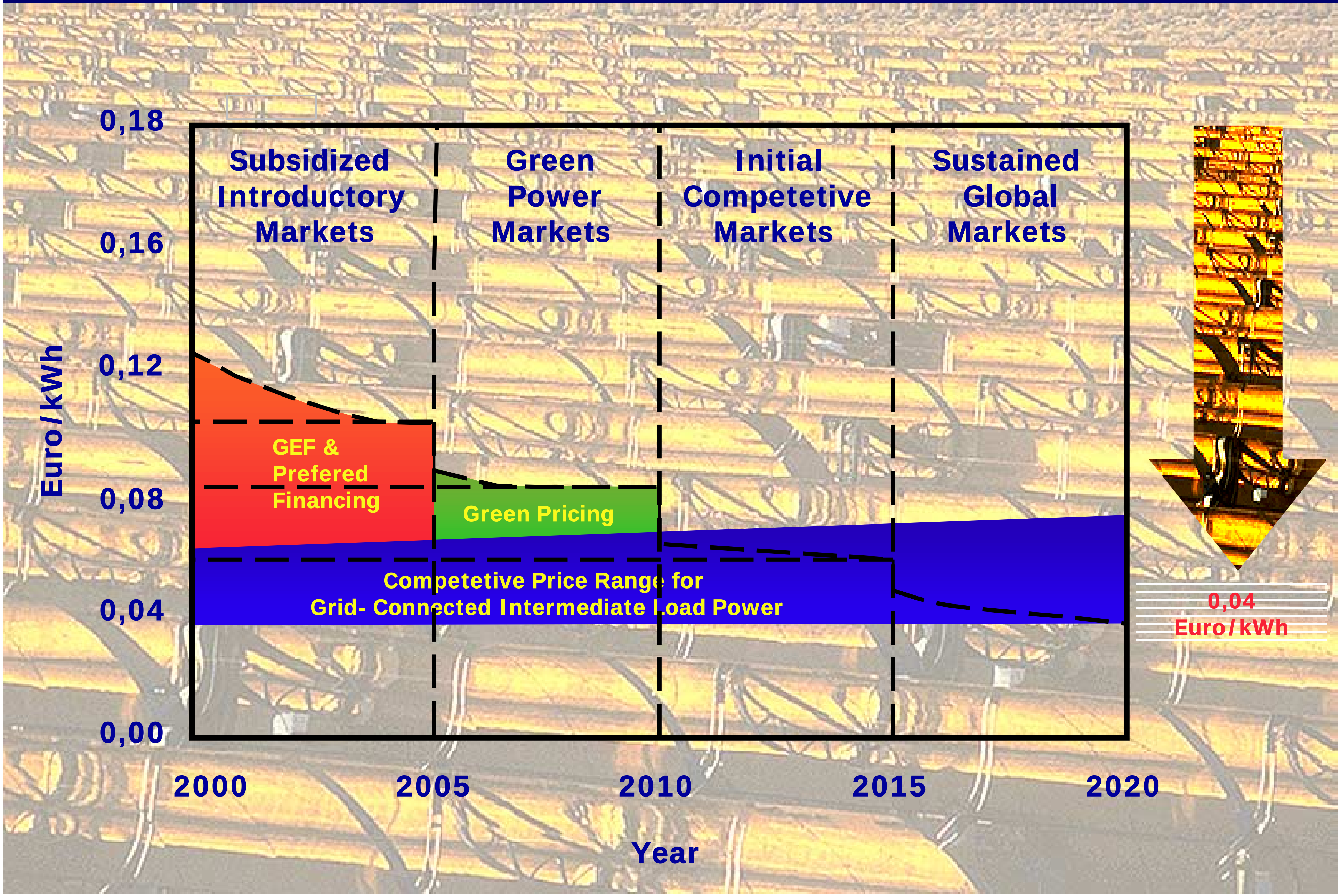
Madison, June 18, 2000

Michael Geyer

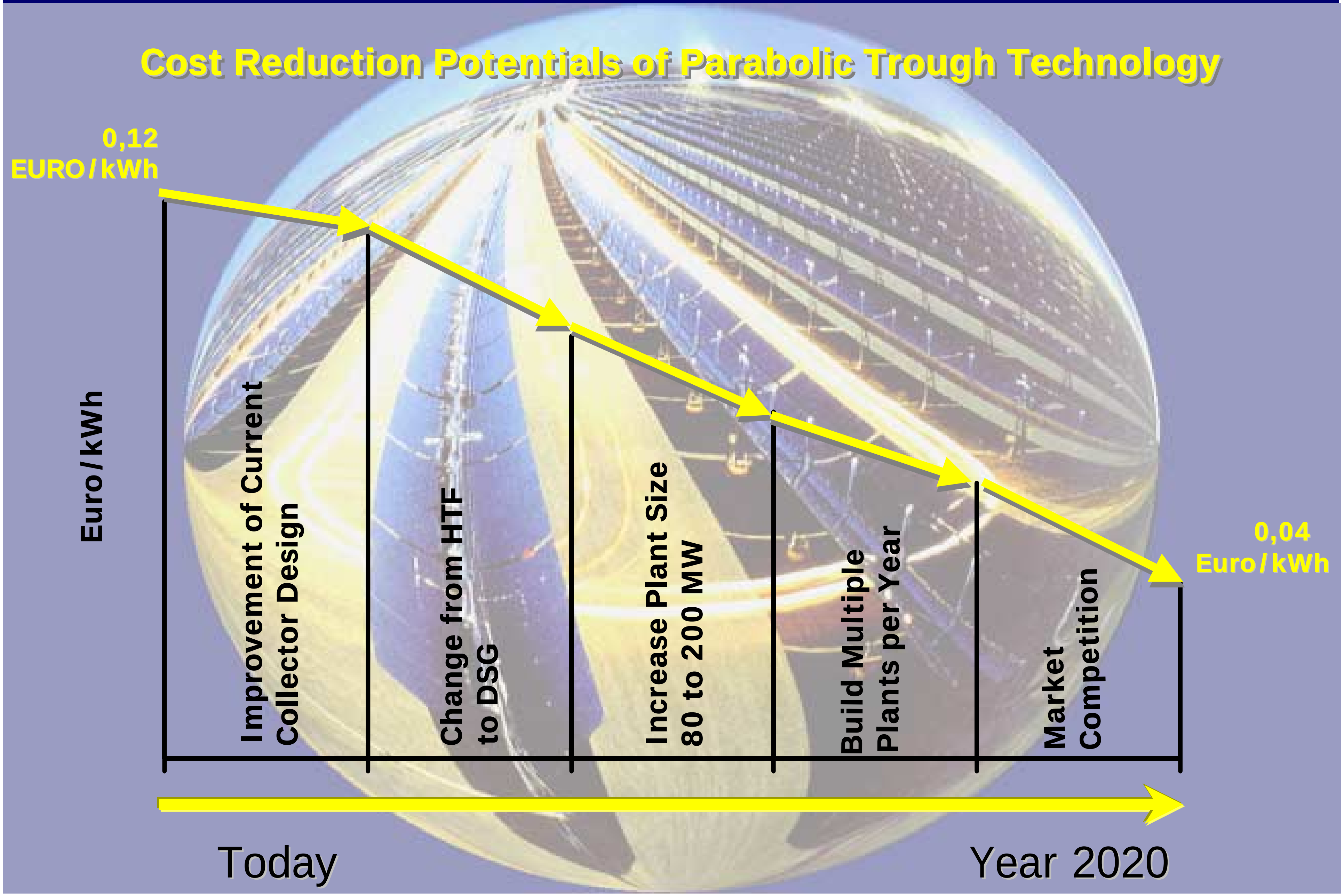
DLR Deutsches Zentrum für Luft- und Raumfahrt

Plataforma Solar de Almeria

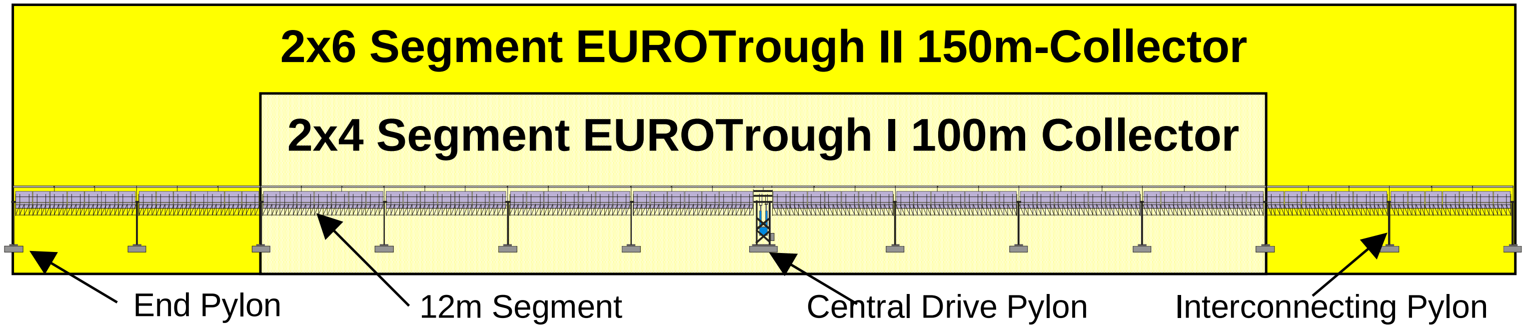
Parabolic Trough Market
Cost Reduction Perspectives



Parabolic Trough Cost Reduction Perspective



EUROTrough I+II Objectives



EUROTrough Phase I
1.8.1998 - 31.1.2001
Cost: 3 Mio Euro
(40%Partners, 40%EU, 20%BMWi)

- Develop 100m/8segment EUROTrough Collector Design
  Deliverable: Manufacturing Dwgs
- Build one half EUROTrough at Plataforma Solar
  Deliverable: 50m Prototype
- Test in PSA's HTF Loop
  Deliverable: Qualification Tests

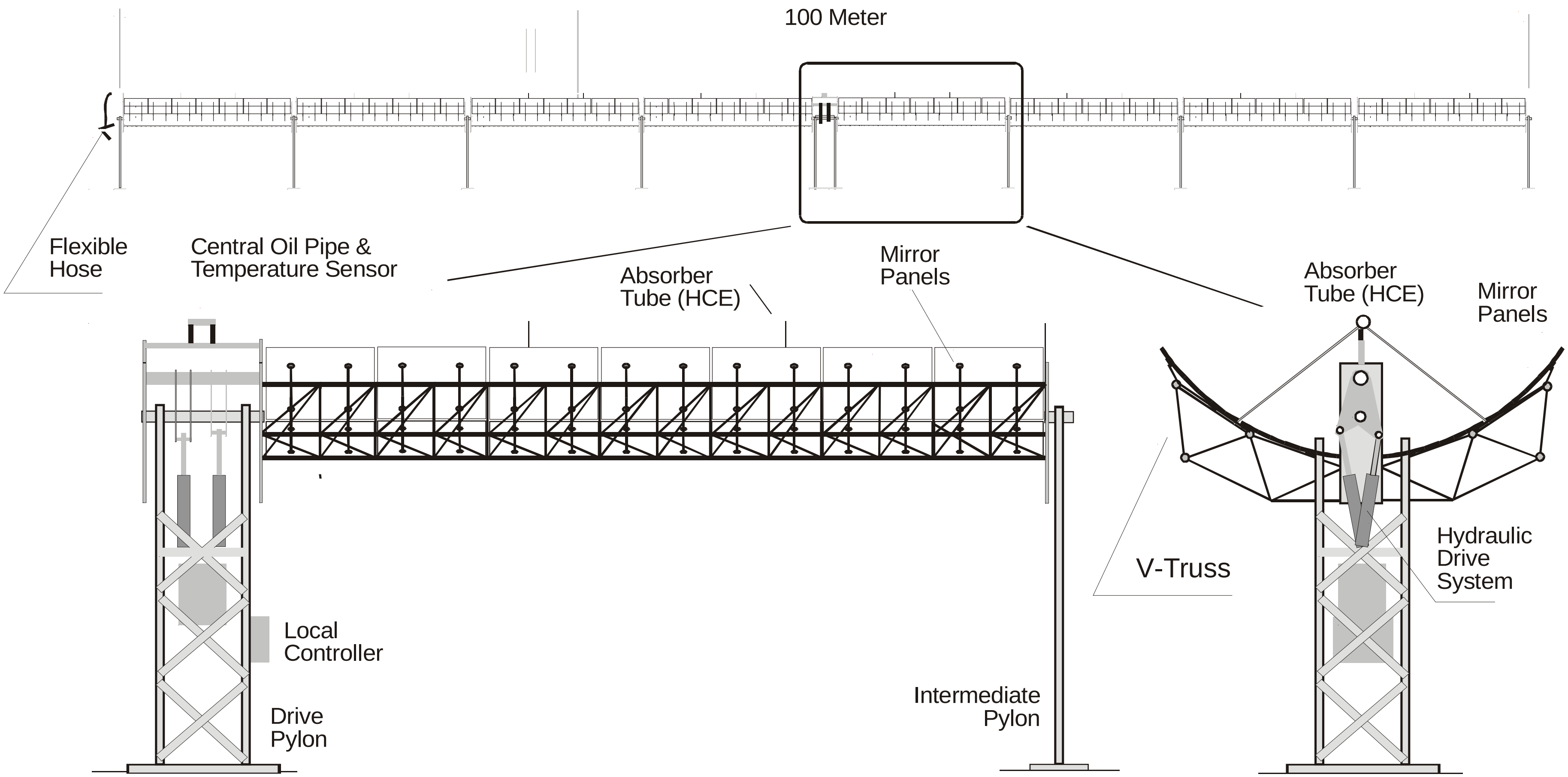
Partners: *Inabensa, Pilkington, SBP, Fichtner, Ciemat, CRES, DLR*

EUROTrough Phase II
1.10.2000 - 31.12.2002
Cost: 2 Mio Euro
(50%Partners, 50%EU)

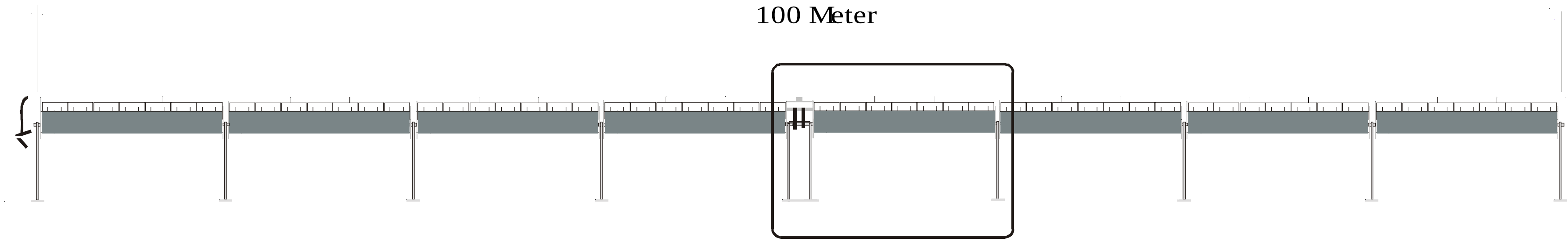
- Develop 150m/12segment EUROTrough Collector Design
  Deliverable: Manufacturing Dwgs
- Add 2 segments to EUROTrough prototype at Plataforma Solar
  Deliverable: 50+25m Prototype
- Test in PSA's HTF Loop
  Deliverable: Qualification Tests

Partners: *Inabensa, Iberdrola, Pilkington, SBP, Solel, Ciemat, DLR*

LS-3 State of the Art

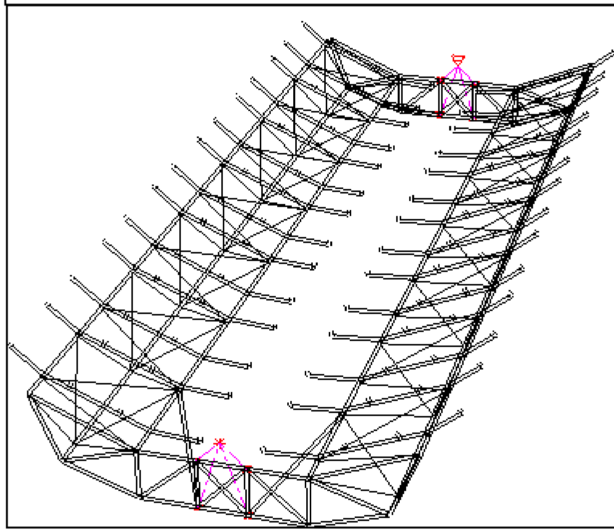
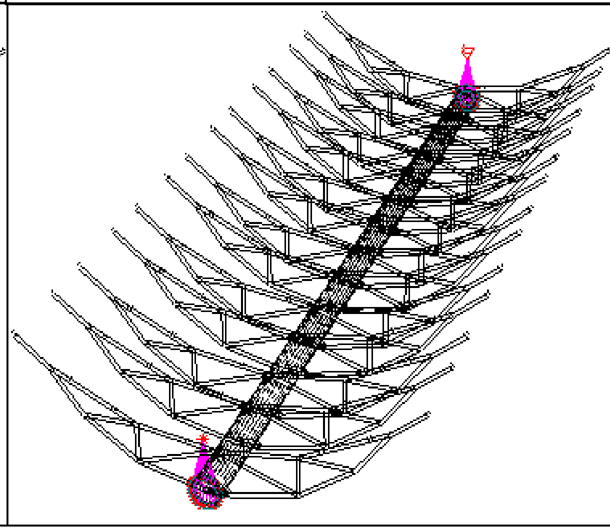
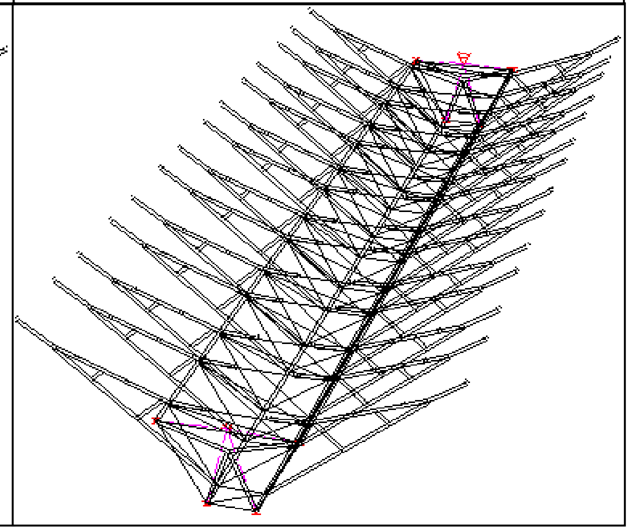


LS-3 State of the Art: Weights



LS-3 Collector	**Strong**	**Regular**
V-Truss Weight	1350 kg	1068 kg
Drive Pylon	315 kg	265 kg
Typical Pylon	135 kg	92 kg
Degree of Material Use (Survival/Stow)	93%	99%
Maximum Wind Bending	6.9mm	10.2mm
Maximum Wind Torsion Surface	5.4mrad	5.5mrad
Maximum Wind Torsion Axis	5.3mrad	7.7mrad

Design Options

LS-3 Space Frame	LS-2 Torque Tube	ET Torque Box
		

EUROTrough Design Procedure

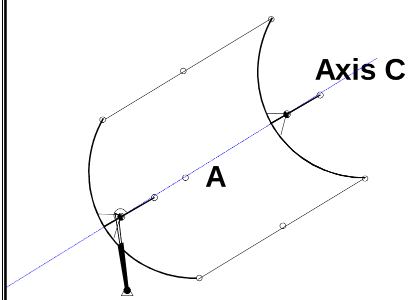
- Elaboration of conceptual design criteria
- Elaboration of design options
- Layout of three different structures
- FEM - analysis of the various structures
- Comparison of design options concerning
  - overall collector mass,
  - deformation in operation,
  - stress under survival loads
- Comparison of design options with LS-3 collector
- Consideration of manufacturing, assembly, transportation and erection cost

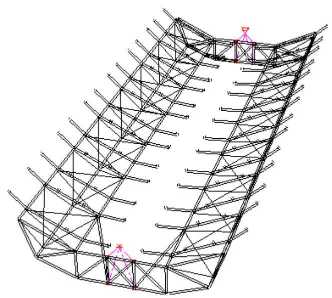
➔ Decision on design options

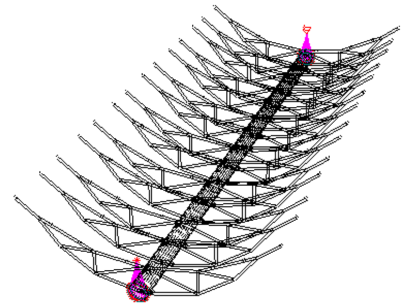
DLR

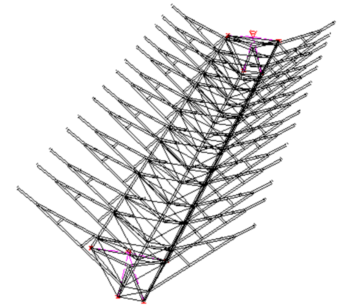
Why the Torque Box Design?

Summary of the FEM Optimizations







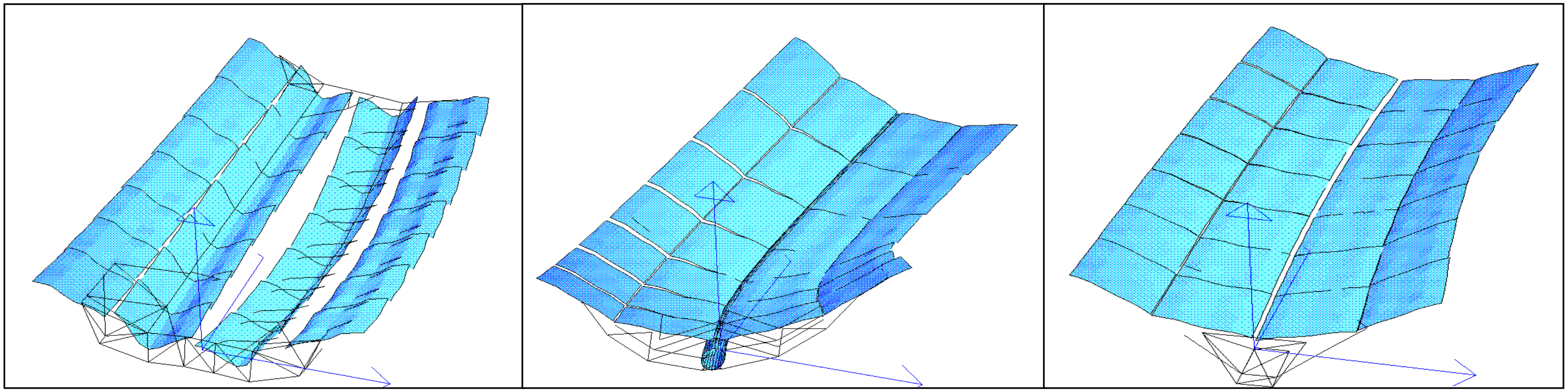


	LSS-3 Space Frame Design	LS-2 Torque Tube Design	ET Torque Box Design
Weight	1045 kg	895 kg	915 kg
Use of Sections (Survival /Stow)	32%	55,5	48%
Maximum Wind Bending Distortion Point A	10,5 mm	35,0 mm	7,08 mm
Maximum Wind Bending Distortion surface	4,15 mrad	1,6 mrad	1,6 mrad
Maximum Wind Torsion Distortion surface	4,2 mrad	1,9 mrad	1,7 mrad
Maximum Wind Torsion Distortion Axis C	4,4 mrad	2,0 mrad	1,69 mrad

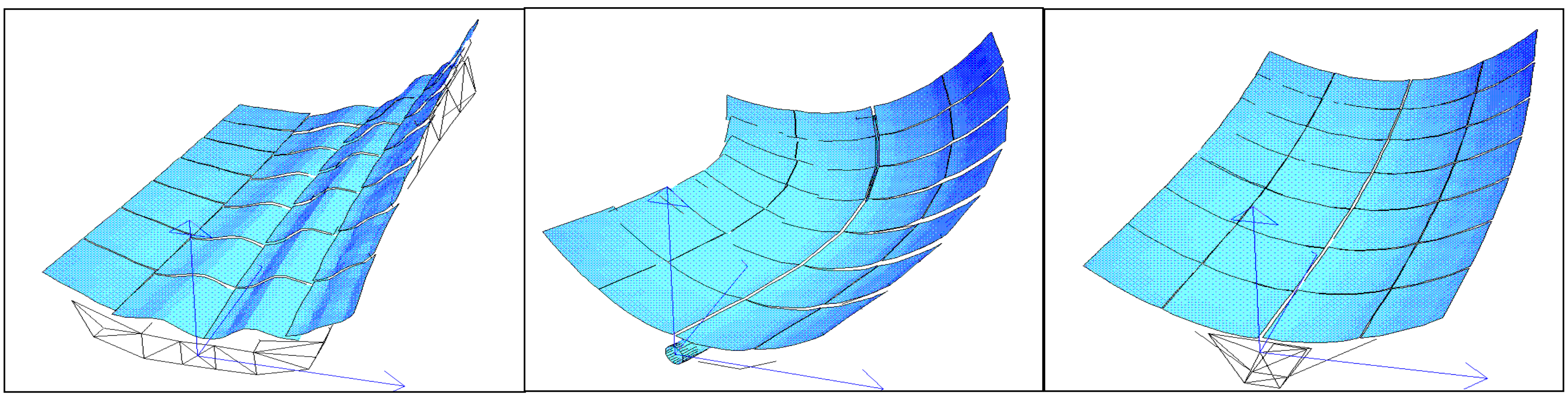
FEM Optimization: Wind Bending and Torsion

LS-3 Space Frame	LS-2 Torque Tube	ET Torque Box

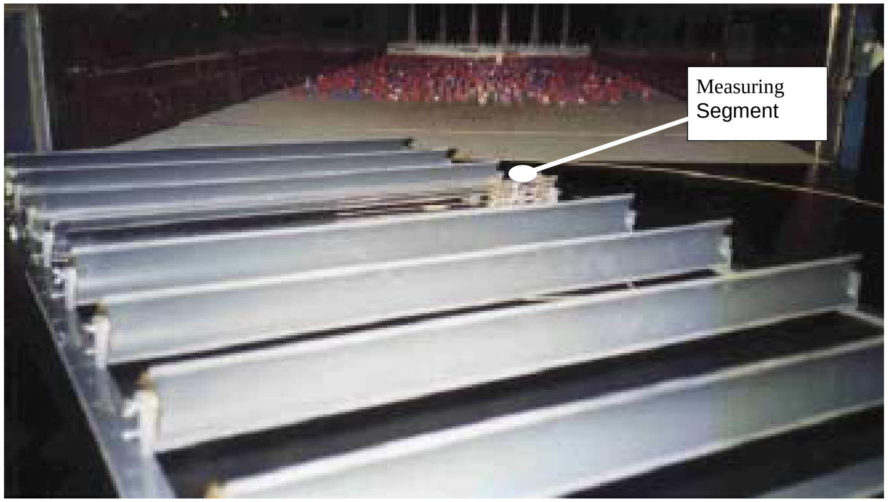
Maximum Wind Bending

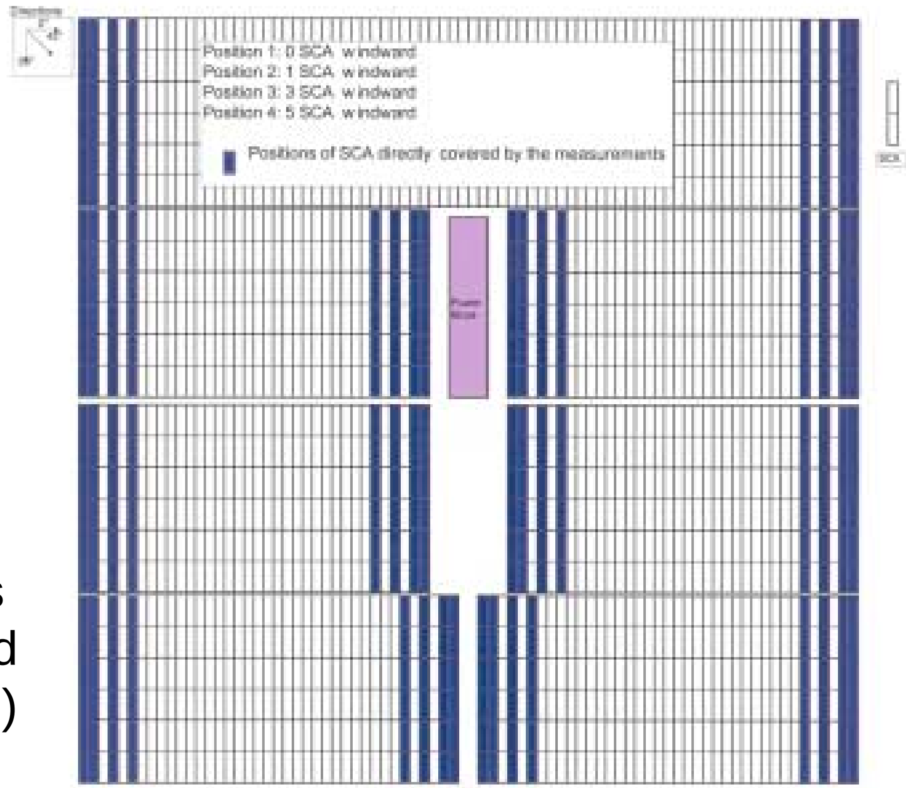


Maximum Wind Torsion



Wind Tunnel Tests

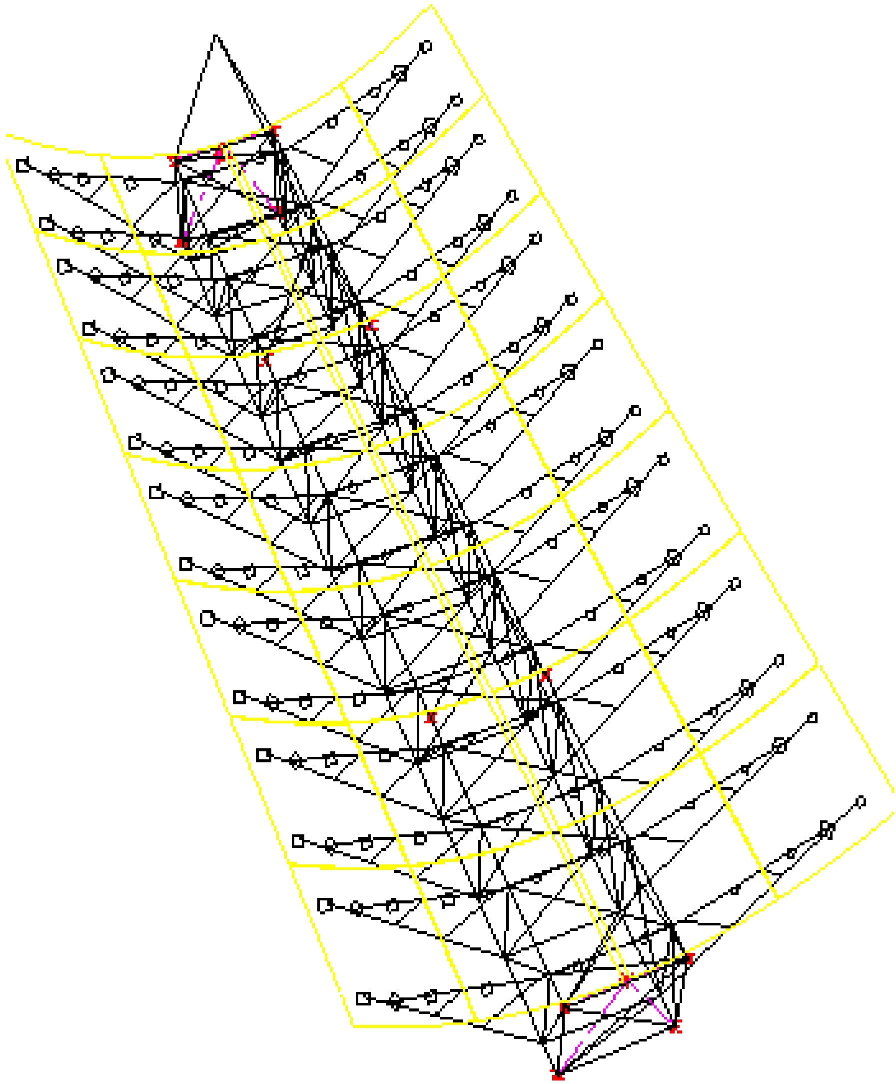




3 different wind directions
5 different positions in the field
(front, 3 in front, 5 in front and single)

Tests performed by:	Wacker Ingenieure, Birkenfeld, Germany
Wind Tunnel Facility:	Wind Tunnel University of Karlsruhe
Model scale:	1 : 86
Test conditions:	Atmospheric boundary layer
Cost:	40’000 EURO

EUROTrough Design Selection



- Torque box design allows weight reduction compared with existing collector design
- Torque box design has the lowest deformations under dead and wind loads
- Torque box design will allow additional collector elements per drive
- Higher structural stiffness will improve collector performance
- Necessary assembly jigs will be more simple and less costly compared with the LS-3 collector

➔ Torque box selected

Final Wind Load Assumptions for EuroTrough

Operation Wind W_{op}:

Definition: Wind speed: **0 m/s – 14,3 m/s** Position: any

Criteria No design criteria

Economic Design Wind $W_{90\%}$:

Definition: Wind speed: **7 m/s** Position: any

Criteria: Deformations (energetic losses) within tolerances

Transient Wind W_{trans}:

Definition: Wind speed: **21 m/s** Position: any

Criteria: Stress within tolerances + maximum drive power

Survival Wind W_{surv}:

Definition: Windspeed: **31,3 m/s** Position: Stow

Criteria: Stress within tolerances

Loading and Material Safety Coefficients

Safety coefficients were reduced compared to EURO-CODE for structural engineering

EUROTrough Design Tolerances

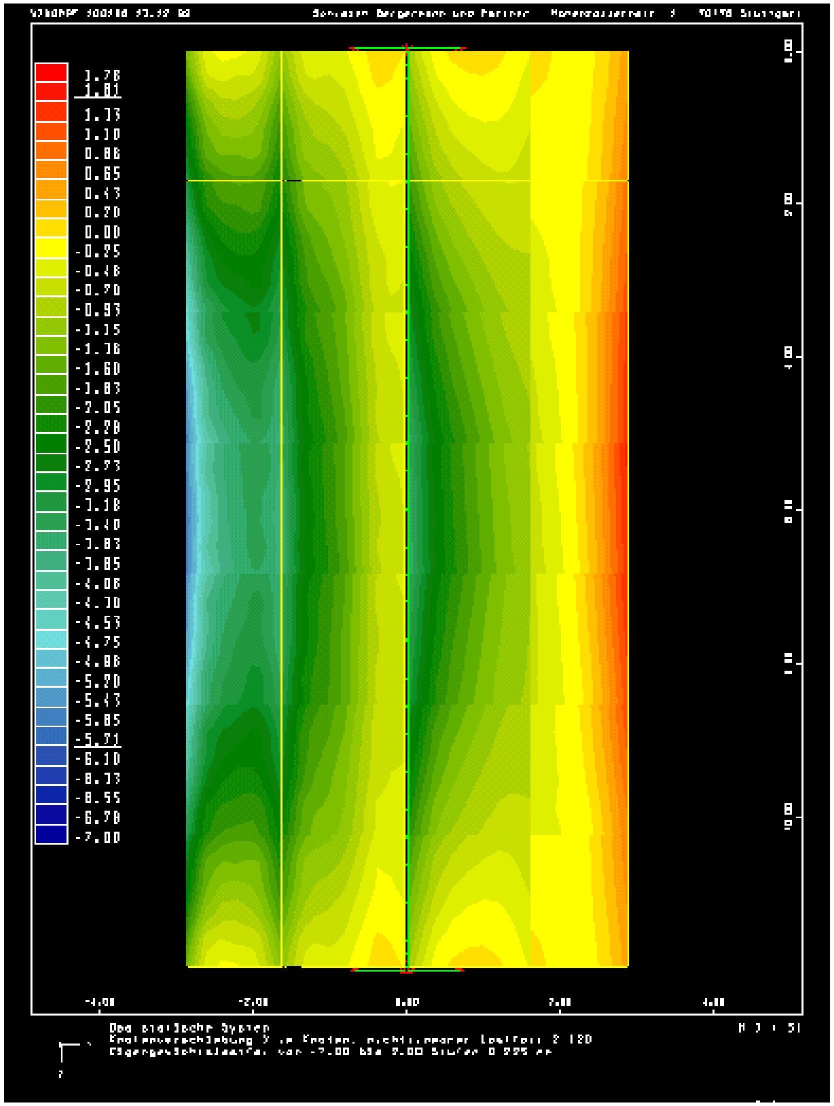
Deformation Tolerances for 12 Segment Collector

Load	Max. Global Torsion mrad	Avg. Surface Distortion mrad	Maximum Displacement mm
Dead Load	-	2	4
Dead Load + Design Wind Load	5	3	6

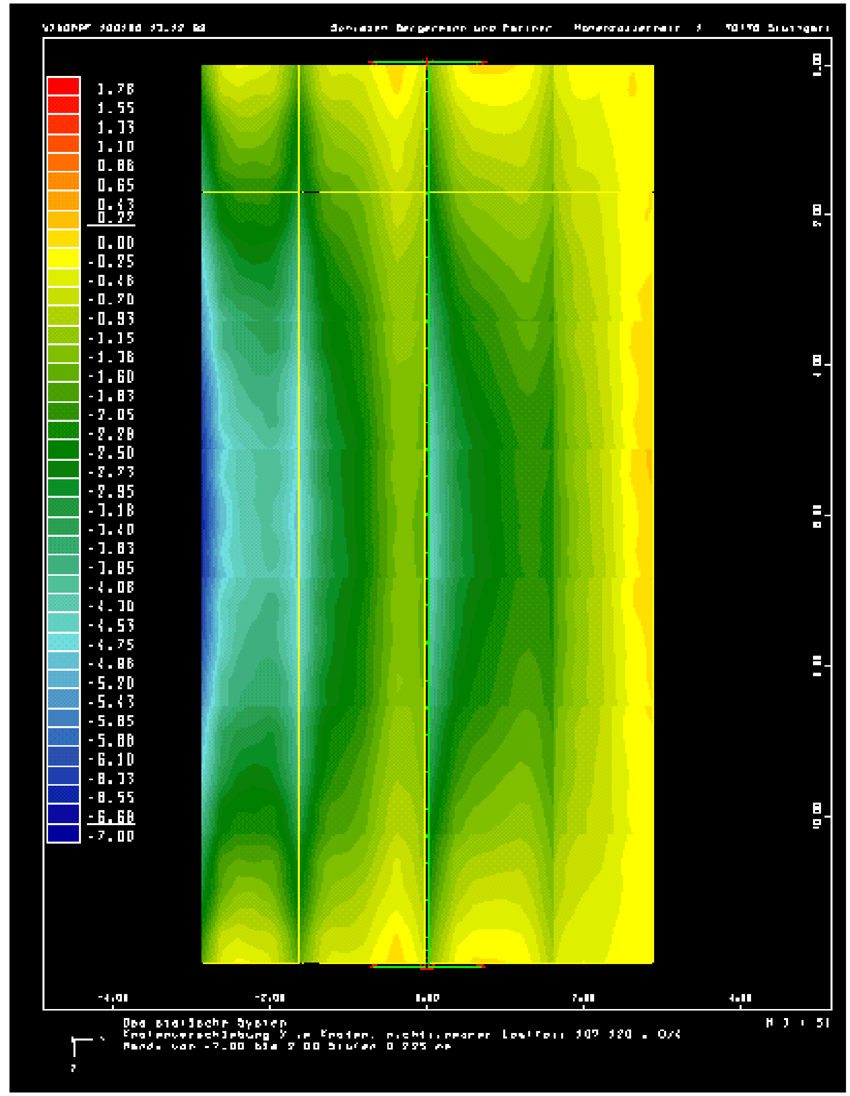
Manufacturing and Installation Tolerances

Reflector Error:	average < 3 mrad
Position of Absorber tube x,y	±10mm, ± 10mm
Lateral deviation of the outer reflector edge	± 5mm
Tracking error	< 3 mrad

Bending at 120°



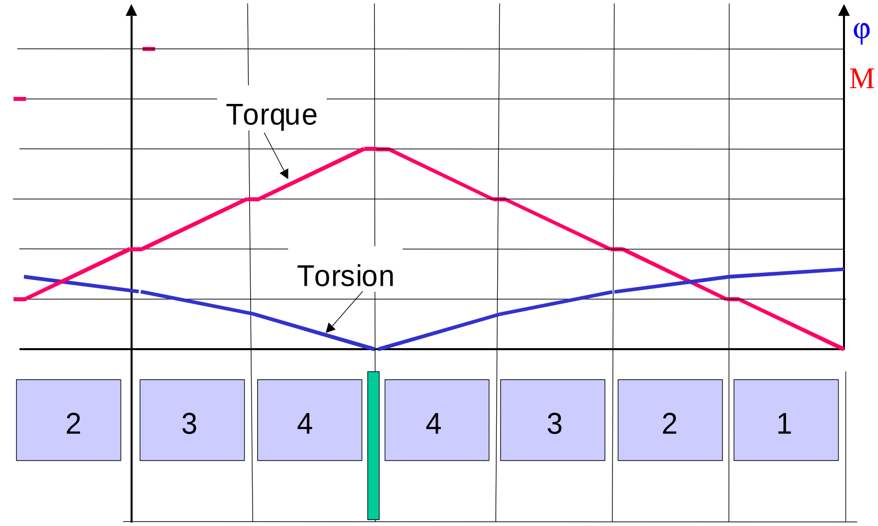
Gravity, No Wind



Gravity, 7m/s Wind

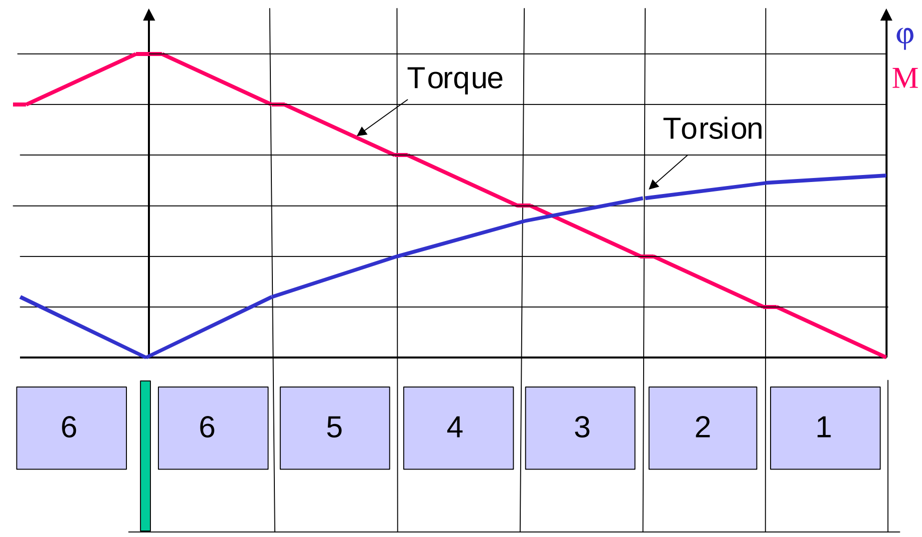
Collector Length vs Torque and Torsion

Increase of torque and deformation due to wind forces for EUROTROUGH with 8 segments per drive



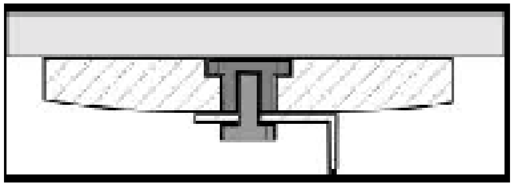
Drive Pylon

Increase of torque and deformation due to wind forces for EUROTrough with 12 segments per drive

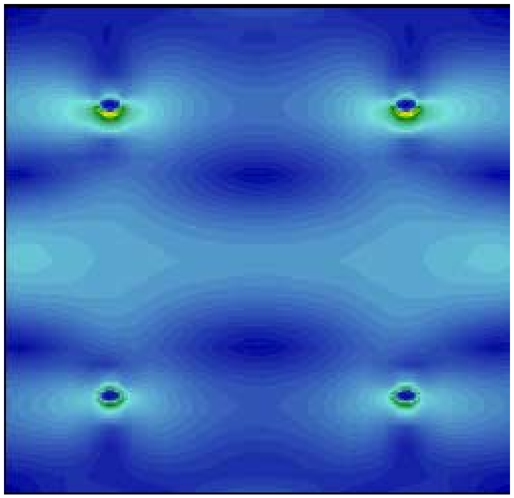


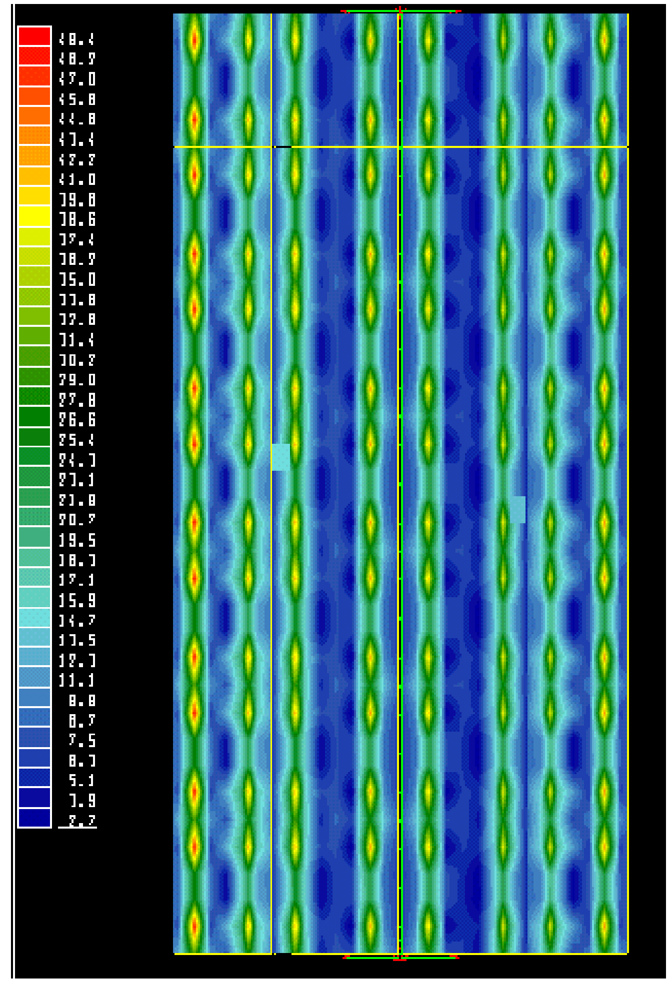
Drive Pylon

Mirror Stress Reduction by 50% vs LS2/LS3



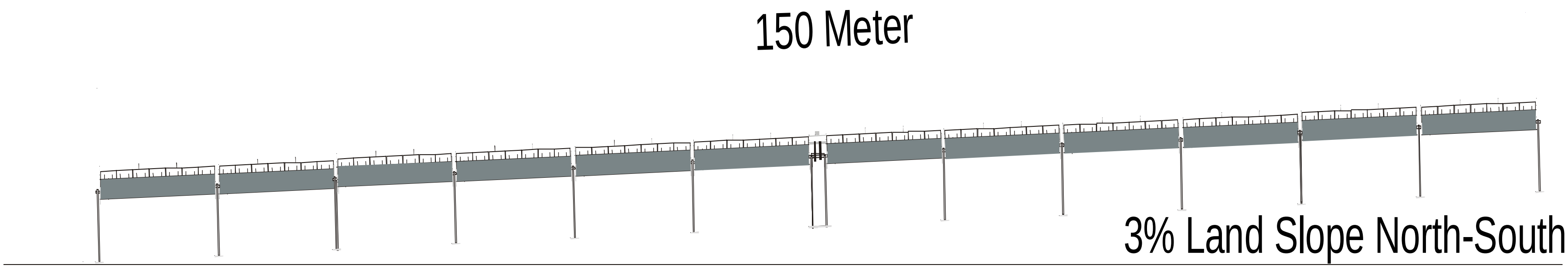
Optimization of
Mirror Fixation





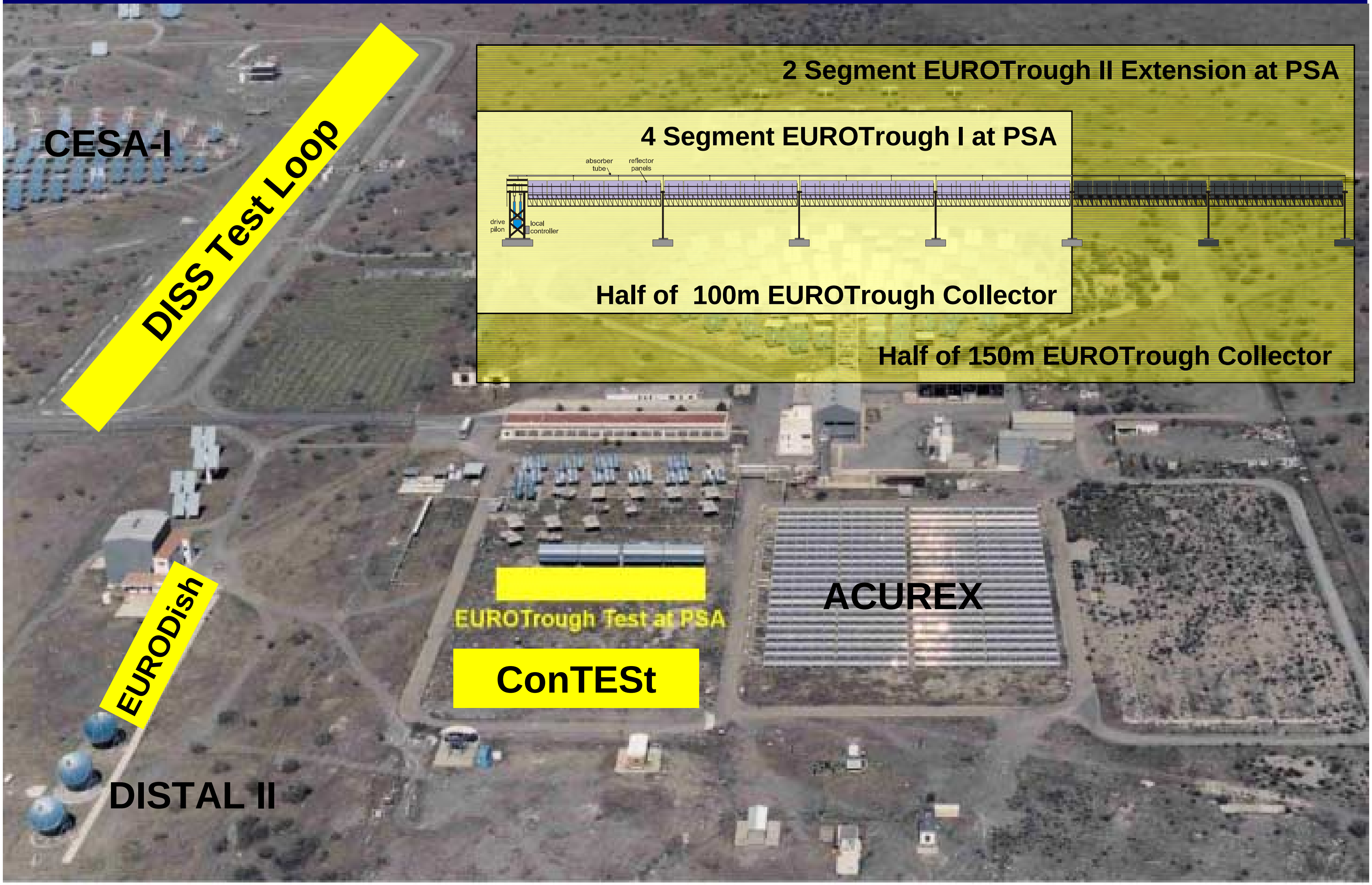
Mirror stress level under survival conditions
Position: Stow; Wind: 31,5 m/s

EUROTrough Design Innovations



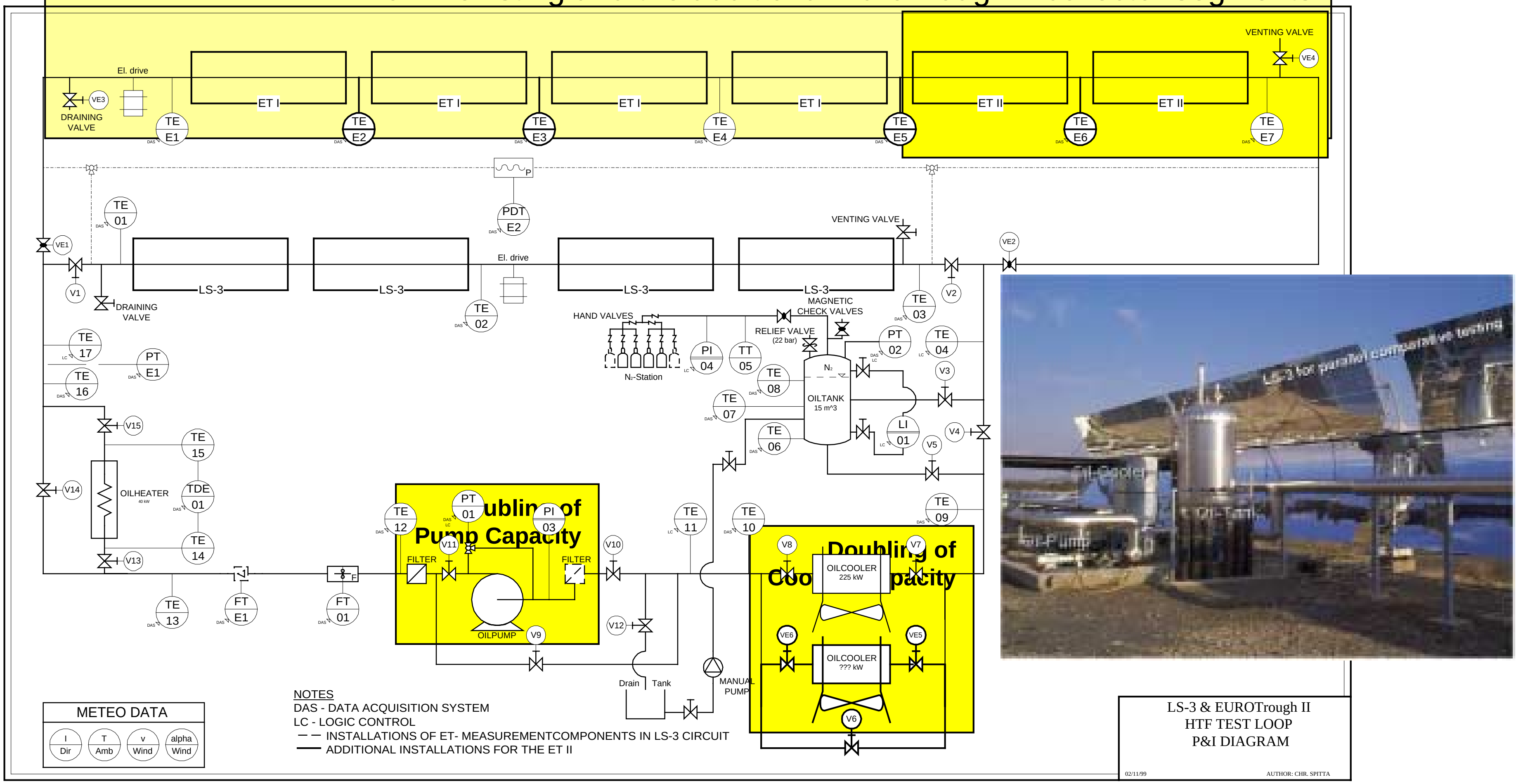
- Torque box with less bending/torsion and reduced weight
- Increase of Collector length up to 150m/12segments
- 50% reduced mirror stress by new pad fixations
- Installation on 3% ground slope with new bearings
- Suitable for HTF and DSG
- Structural part items minimized to reduce transport cost
- Rig cost and assembly cost reduced
- New tracking control

EUROTrough Prototype Test at PSA



EUROTrough Prototype Testloop at PSA

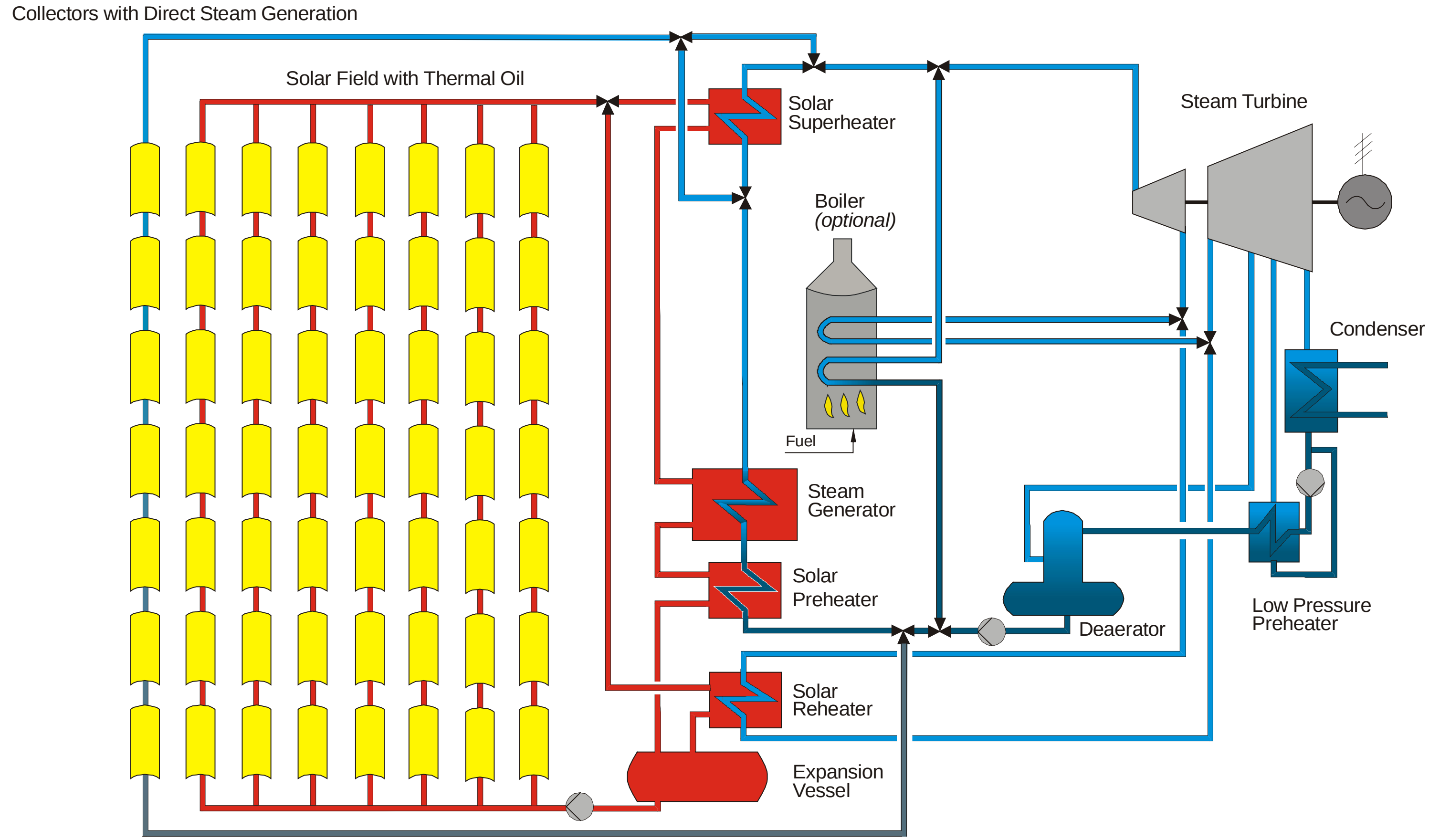
New hardware and measurement equipment in EUROTrough II:
Parallel comparative testing of EUROTrough II and LS-3
Torque, bending, twisting, stress, acceleration and vibration measurement
on 4 existing and the additional EuroTrough II collector segments



DLR

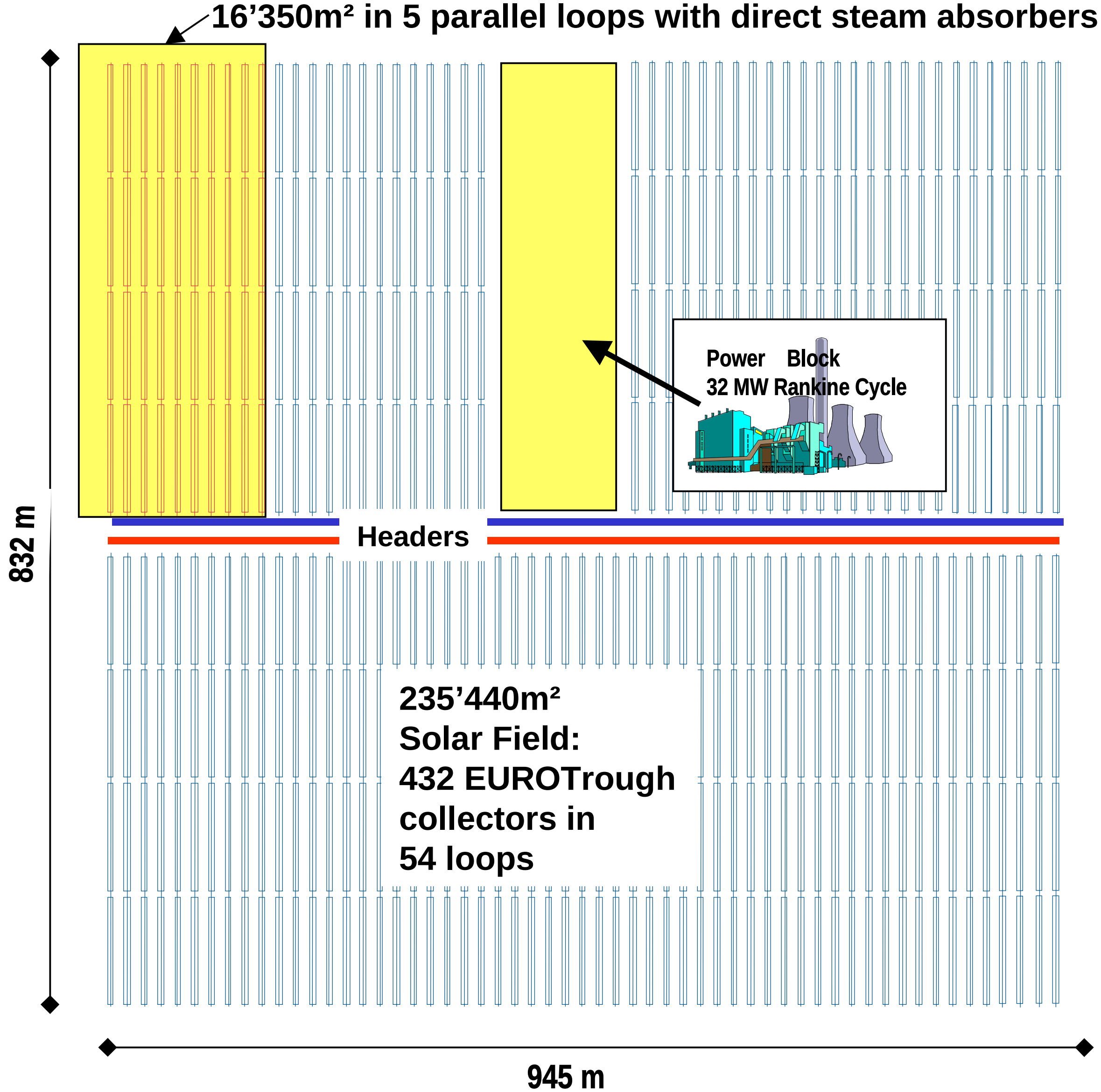
Consortium Agreement
Marketing Strategy
International Cooperation

AndaSol32: 1st Project with EUROTrough & DSG



AndaSol32 Partners: Gamesa, Iberdrola, Agrosol, Pilkington/Flabeg, Solar Millennium AG, DLR, Ciemat

AndaSol32: 235’000m² EUROTrough & 16’000m² DSG



Solar Thermal Market Problems

Solar Thermal (like all Renewables)

- is not competitive with least cost conventional alternatives
- needs financial subsidies (grants, kWh premiums, tax credits, soft loans, credit warranties, …)
- needs political support from national, multinational (I.e EU) or multilateral organisations to achieve market introduction

Solar Thermal Market Problems

National Governments

- don’t like subsidize with their national taxes foreign suppliers (1cent/kWh premium fo a 50MW solar plant is 1 Mio USD subsidy per year)
- want to earn merits and votes with creation of jobs, local hi´tec, etc.
- don’t support any “not invented here”

Multinational Donors (like EU) want

- involvement of their members

Multilateral Institutions (like World Bank, GEF)

- fair competition

Solar Thermal Market Problems

In this phase, solar thermal industrial developers must avoid

- create a broad jealousy of the non-profiting companies in the renewable scene, who will intervene against subsidy and support at the national level

EUROTrough Approach

Based on these lessons learnt in Spain and in Brussels, the EUROTrough partners have committed themselves in their consortium agreement to

- open the EUROTrough platform (as the PC platform)
- intend to distribute the design widely
- by giving every partner the right to license the design to any client (even the competitors of other partners)

in order to give a broad community the chance to make money with solar thermal thru EUROTrough

Example: ANDASOL proposal

How Can the Partners Nevertheless Make Money?

The EUROTrough Consortium follows the principle:

- Give Away Kerosene Lamps and Sell Kerosene
- Give Away Cell-Phones for 1$ and Profit from the Calls
- Open the Trough Platform like in the PC Business to competition and gain a market
- Make EUROTrough national anywhere
- Make EUROTrough “invented there”
- Involve from the beginning other national and international players to gain their lobbying support

Consortium Agreement

The EUROTrough Consortium

- **does not want to make the money with the EUROTrough design itself, but wants**
- **to sell equipment (mirrors, structures, absorbers, trackers)**
- **and to sell services (project development, engineering, management, operation, construction, …)**

Like in the PC business, where nobody wants to invent himself a costly operating system or hardware bus, power project developers don’t want to spend their money in reinventing and requalifying the parabolic trough. They want to spend minimum money in that and would rather use standard solutions. (Only within the solar thermal community we all have the desire to invent our own collector and solar concept…)

Offer of EUROTrough to US Firms

In view of the limited resources for solar thermal, the EUROTrough Consortium advocates to

- **join forces between Europe and US**
- **avoid duplication of efforts**

The EUROTrough Consortium offers to

- **fully share the EUROTrough Design with interested US partners**
- **bring it into a joint NEXTrough US-European effort**

The EUROTrough Consortium proposes

- **prequalify the EUROTrough in a prototype test at PSA**
- **demonstrate a loop of 8 Collectors at Kramer Junction**
- **jointly develop commercial scale projects**

Solar Thermal Market Problems